What is claimed is:

1. A substrate processing apparatus comprising:

a process chamber capable of processing a substrate;

a radiation source capable of providing non-polarized radiation that is at least partially reflected from a substrate in the chamber;

a radiation detector adapted to detect the reflected radiation and generate a signal; and

a controller adapted to receive the signal and determine a property of a material on the substrate in the chamber.

2. An apparatus according to claim 1 wherein the controller determines the property of the material substantially only from a change in amplitude of the reflected radiation.

3. An apparatus according to claim 2 wherein the controller determines the property of the material from a change in amplitude that is characterized by a constructive or destructive interference of a radiation component reflected from the substrate surface and another radiation component transmitted through the material and reflected from an underlying interface.

4. An apparatus according to claim 1 wherein the controller is adapted to determine a thickness of the material on the substrate.

5. An apparatus according to claim 1 wherein the substrate comprises first and second materials, and wherein the controller is adapted to determine a thickness of the second material while a first material is being processed on the substrate.

6. An apparatus according to claim 1 wherein the controller is adapted to determine a crystalline, microstructure, porosity, electrical, chemical or compositional property of the material.

7. An apparatus according to claim 1 wherein the controller is further adapted to detect both an onset and completion of processing of a plurality of materials on the substrate.

8. A method of processing a substrate in a process zone, the method comprising the steps of:

(a) placing the substrate in the process zone;

(b) detecting non-polarized radiation reflected from the substrate before, during, or after processing of the substrate; and

(c) evaluating the detected radiation to determine a property of a material on the substrate in the chamber.

9. A method according to claim 8 comprising determining the property of the material on the substrate from a change in amplitude of the reflected radiation.

10. A method according to claim 9 comprising determining the property of the material on the substrate from a change in amplitude characterized by a constructive or destructive interference of a radiation component reflected from the substrate surface and another radiation component transmitted through a thickness of the material and reflected from one or more underlying interfaces.

11. A method according to claim 8 comprising setting process conditions to process a first material on the substrate and determining a thickness of an underlying second material.

12. A method according to claim 8 comprising determining a crystalline, microstructure, porosity, electrical, chemical or compositional property of the material.

13. A substrate processing apparatus comprising:

(a) a chamber capable of processing a substrate;

(b) a radiation source capable of providing non-polarized radiation that is at least partially reflected from a substrate in the chamber;

(c) a radiation detector adapted to detect the reflected radiation and generate a signal; and

(d) a computer having a memory capable of operating a computer-readable program embodied on a computer-readable medium, the computer readable program including program code to receive the signal and determine a property of a material on the substrate in the chamber.

14. An apparatus according to claim 13 wherein the program code determines a property of the material from a change in amplitude of the reflected radiation.

15. A substrate processing apparatus comprising:

(a) a process chamber capable of processing a substrate;

(b) a radiation source capable of providing radiation that is at least partially reflected from the substrate during processing;

(c) a radiation detector adapted to detect the reflected radiation and generate a signal; and

(d) a controller adapted to receive the signal and determine both an onset and a completion of processing of a material on the substrate.

16. An apparatus according to claim 15 wherein first and second materials are processed on the substrate, and wherein the controller is adapted to detect the onset and completion of processing of both materials.

17. An apparatus according to claim 15 wherein the onset or completion of processing is detected from a change in amplitude of the reflected radiation.

18. A method of processing a substrate in a process zone, the method comprising the steps of:

(a) placing the substrate in the process zone;

(b) setting process conditions in the process zone to process the substrate;

(c) detecting radiation reflected from the substrate during processing;

(d) determining an onset of processing of a material on the substrate; and

(e) determining a completion of processing of the material.

19. A method according to claim 18 comprising determining the onset and completion of processing from a change in amplitude of the reflected radiation.

20. A method according to claim 19 wherein the change in amplitude results from changes in the reflectivity or thickness of the material.

21. A method according to claim 19 wherein the change in amplitude is characterized by a constructive or destructive interference of radiation reflected from the substrate surface and radiation transmitted through a thickness of the material and reflected from one or more underlying interfaces.

22. A substrate processing apparatus comprising:

(a) a chamber capable of processing a substrate;

(b) a radiation source capable of providing radiation that is at least partially reflected from the substrate during processing;

(c) a radiation detector adapted to detect the reflected radiation and generate a signal; and

(d) a computer having a memory capable of operating computer-readable program embodied on a computer-readable medium, the computer readable program including program code to receive the signal and detect an onset and completion of processing of a material on the substrate.

23. A substrate processing apparatus comprising:

a process chamber capable of processing a substrate in a plasma;

one or more radiation detectors to detect a radiation emission from the plasma and generate a first signal, and to detect a radiation reflected from the substrate and generate a second signal; and

a controller adapted to receive the first and second signals.

24. An apparatus according to claim 23 wherein the controller is adapted to evaluate the first and second signals to determine an event in the chamber or a property of a material on the substrate.

25. An apparatus according to claim 23 wherein the controller is adapted to evaluate the first and second signals to determine an onset of processing of a material on the substrate.

26. An apparatus according to claim 25 wherein the controller is adapted to evaluate the first and second signals to determine an onset of processing of an underlayer while an overlayer is being processed.

27. An apparatus according to claim 23 wherein the controller is adapted to combine the first and second signals.

28. An apparatus according to claim 23 wherein the controller is adapted to evaluate a derivative of the first and second signals.

29. An apparatus according to claim 23 wherein the controller is adapted to determine a thickness or a crystalline, microstructure, porosity, electrical, chemical or compositional property.

30. An apparatus according to claim 23 wherein the controller is adapted to detect both an onset and completion of processing of a material on the substrate.

31. A method of processing a substrate in a process zone, the method comprising the steps of:

(a) placing the substrate in the process zone;

(b) setting process conditions in the process zone to form a plasma to process the substrate;

(c) detecting a radiation emission from the plasma and generating a first signal;

(d) detecting a radiation reflected from the substrate and generating a second signal; and

(e) evaluating the first and second signals to determine the occurrence of an event in the process zone or a property of a material on the substrate.

32. A method according to claim 31 comprising evaluating the first and second signals to determine an onset of processing of a material on the substrate.

33. A method according to claim 31 comprising evaluating the first and second signals to determine an onset of processing of an underlayer while an overlayer is being processed.

34. A method according to claim 31 comprising combining the first and second signals.

35. A method according to claim 31 comprising determining a derivative of the first and second signals.

36. A substrate processing apparatus comprising:

(a) a chamber capable of processing a substrate in a plasma;

(b) one or more radiation detectors to detect radiation emitted from the plasma and generate a first signal, and to detect radiation reflected from the substrate and generate a second signal; and

(c) a computer having a memory capable of operating a computer-readable program embodied on a computer-readable medium, the computer

readable program including program code to receive the first and second signals and determine an event in the chamber or a property of a material on the substrate.

37. An apparatus according to claim 36 wherein the program code determines a property of the material from a change in amplitude of the radiation.

38. A substrate processing apparatus comprising:

a chamber capable of processing a substrate;

a radiation source capable of providing radiation that is at least partially reflected from a substrate in the chamber;

a radiation detector adapted to detect the reflected radiation and generate a signal; and

a controller adapted to receive the signal and determine the thickness of a material on the substrate.

39. An apparatus according to claim 38 wherein the controller determines the thickness from a change in amplitude of the reflected radiation.

40. An apparatus according to claim 39 wherein the change in amplitude comprises a change in a dynamic variance of the amplitude at a predetermined time.

41. An apparatus according to claim 40 wherein the controller determines the thickness by comparing the change in dynamic variance of the amplitude with a calculated or stored value.

42. An apparatus according to claim 41 wherein the calculated or stored value is obtained for etching of polysilicon or dielectric.

43. An apparatus according to claim 38 wherein the controller is adapted to provide an instruction signal to remove the substrate from the chamber, end processing, or adjust process conditions, upon a determination of an unsuitable thickness of the material on the substrate.

44. A method of processing a substrate in a process zone, the method comprising the steps of:

(a) placing the substrate in the process zone;

(b) detecting radiation reflected from the substrate before, during, or after processing of the substrate; and

(c) evaluating the detected radiation to determine a thickness of a material on the substrate.

45. A method according to claim 44 comprising determining the thickness from a change in amplitude of the reflected radiation.

46. A method according to claim 44 comprising determining the thickness by comparing the change in dynamic variance with a calculated or stored value.

47. A substrate processing apparatus comprising:

(a) a chamber capable of processing a substrate;

(b) a radiation source capable of providing radiation that is at least partially reflected from the substrate during processing;

(c) a radiation detector adapted to detect the reflected radiation and generate a signal; and

(d) a computer having a memory capable of operating a computer-readable program embodied on a computer-readable medium, the computer readable program including program code to receive the signal and determine the thickness of a material on the substrate.

48. A substrate processing apparatus comprising:

a chamber capable of processing a substrate;

a radiation source capable of providing radiation that is at least partially reflected from a substrate in the chamber;

a radiation detector adapted to detect the reflected radiation and generate a signal; and

a controller adapted to receive the signal and determine a dopant level of a material on the substrate.

49. An apparatus according to claim 48 wherein the controller determines the dopant level from a change in amplitude of the reflected radiation.

50. An apparatus according to claim 49 wherein the change in amplitude comprises a change in a dynamic variance of the amplitude at a predetermined time.

51. An apparatus according to claim 50 wherein the controller determines the dopant level by comparing the change in dynamic variance of the amplitude with a calculated or stored value.

52. An apparatus according to claim 51 wherein the calculated or stored value is obtained for etching of polysilicon or dielectric.

53. An apparatus according to claim 48 wherein the controller is adapted to provide an instruction signal to remove the substrate from the chamber, end processing, or adjust process conditions, upon a determination of an unsuitable dopant level of the material on the substrate.

54. A method of processing a substrate in a process zone, the method comprising the steps of:

(a) placing the substrate in the process zone;

(b) detecting radiation reflected from the substrate before, during, or after processing of the substrate; and

(c) evaluating the detected radiation to determine the dopant level of a material on the substrate.

55. A method according to claim 54 comprising determining the dopant level from a change in amplitude of the reflected radiation.

56. A method according to claim 55 comprising determining the dopant level by comparing a change in dynamic variance of the amplitude with a calculated or stored value.

57. A substrate processing apparatus comprising:

(a) a chamber capable of processing a substrate;

(b) a radiation source capable of providing radiation that is at least partially reflected from the substrate during processing;

(c) a radiation detector adapted to detect the reflected radiation and generate a signal; and

(d) a computer having a memory capable of operating a computer-readable program embodied on a computer-readable medium, the computer readable program including program code to receive the signal and determine a dopant level of a material on the substrate.

58. A substrate processing apparatus comprising:

a chamber capable of processing a substrate;

a radiation source capable of providing radiation that is at least partially reflected from a substrate in the chamber;

a radiation detector adapted to detect the reflected radiation and generate a signal; and

a controller adapted to receive the signal and determine a trench depth on the substrate.

59. An apparatus according to claim 58 wherein the controller determines the trench depth from a change in amplitude of the reflected radiation.

60. An apparatus according to claim 59 wherein the change in amplitude comprises a change in a dynamic variance of the amplitude at a predetermined time.

61. An apparatus according to claim 60 wherein the controller determines the trench depth by comparing the change in dynamic variance of the amplitude with a calculated or stored value.

62. An apparatus according to claim 61 wherein the calculated or stored value is obtained for etching of polysilicon or dielectric.

63. An apparatus according to claim 58 wherein the controller is adapted to provide an instruction signal to remove the substrate from the chamber, end processing, or adjust process conditions, upon a determination of an unsuitable trench depth on the substrate.

64. A method of processing a substrate in a process zone, the method comprising the steps of:

(a) placing the substrate in the process zone;

(b) detecting radiation reflected from the substrate before, during, or after processing of the substrate; and

(c) evaluating the detected radiation to determine a trench depth on the substrate.

65. A method according to claim 64 comprising determining the trench depth from a change in amplitude of the reflected radiation.

66. A method according to claim 65 comprising determining the trench depth by comparing the change in dynamic variance of the amplitude with a calculated or stored value.

67. A substrate processing apparatus comprising:

(a) a chamber capable of processing a substrate;

(b) a radiation source capable of providing radiation that is at least partially reflected from the substrate during processing;

(c) a radiation detector adapted to detect the reflected radiation and generate a signal; and

(d) a computer having a memory capable of operating a computer-readable program embodied on a computer-readable medium, the computer readable program including program code to receive the signal and determine a trench depth on the substrate.

68. A substrate processing apparatus comprising:

a chamber capable of processing a substrate;

a radiation source capable of providing radiation that is at least partially reflected from a substrate in the chamber;

a radiation detector adapted to detect the reflected radiation and generate a signal; and

a controller adapted to receive the signal and determine a trench corner rounding value on the substrate.

69. An apparatus according to claim 68 wherein the controller determines the trench corner rounding value from a change in amplitude of the reflected radiation.

70. An apparatus according to claim 69 wherein the amplitude change comprises a change in a dynamic variance of the amplitude at a predetermined time.

71. An apparatus according to claim 70 wherein the controller determines the trench corner rounding value by comparing the change in dynamic variance of the amplitude with a calculated or stored value.

72. An apparatus according to claim 71 wherein the calculated or stored value is obtained for etching of polysilicon or dielectric.

73. An apparatus according to claim 68 wherein the controller is adapted to provide an instruction signal to remove the substrate from the chamber, end processing, or adjust process conditions, upon a determination of an unsuitable trench corner rounding value.

74. A method of processing a substrate in a process zone, the method comprising the steps of:

(a) placing the substrate in the process zone;

(b) detecting radiation reflected from the substrate before, during, or after processing of the substrate; and

(c) evaluating the detected radiation to determine a trench corner rounding value on the substrate.

75. A method according to claim 74 comprising determining the trench corner rounding value from a change in amplitude of the reflected radiation.

76. A method according to claim 75 comprising determining the trench corner rounding value by comparing a change in dynamic variance of the amplitude with a calculated or stored value.

77. A substrate processing apparatus comprising:

(a) a chamber capable of processing a substrate;

(b) a radiation source capable of providing radiation that is at least partially reflected from the substrate during processing;

(c) a radiation detector adapted to detect the reflected radiation and generate a signal; and

(d) a computer having a memory capable of operating a computer-readable program embodied on a computer-readable medium, the computer readable program including program code to receive the signal and determine a trench corner rounding value on the substrate.

78. A substrate processing apparatus comprising:

a chamber capable of processing a substrate;

a radiation source capable of providing radiation that is at least partially reflected from a substrate in the chamber;

a radiation detector adapted to detect the reflected radiation and generate a signal; and

a controller adapted to receive the signal and evaluate an amplitude change of the reflected radiation in relation to a calculated or stored range of amplitude changes for a batch of substrates.

79. An apparatus according to claim 78 wherein the controller evaluates the amplitude change to determine if the amplitude change is within the calculated or stored range.

80. An apparatus according to claim 78 wherein the controller is further adapted to provide an instruction signal to remove the substrate from the chamber, end processing, or adjust process conditions, in response to the evaluation of the amplitude change.

81. An apparatus according to claim 78 wherein the controller is adapted to provide the instruction signal at the beginning of processing of the substrate.

82. An apparatus according to claim 78 wherein the amplitude change comprises a change in a dynamic variance of the amplitude.

83. A method of processing a substrate in a process zone, the method comprising the steps of:

(a) placing the substrate in the process zone;

(b) detecting radiation reflected from the substrate before, during, or after processing of the substrate; and

(c) evaluating an amplitude change of the reflected radiation relative to a calculated or stored range of amplitude changes for a batch of substrates.

84. A method according to claim 83 wherein the step (c) comprises determining if the amplitude change is within the calculated or stored range.

85. A method according to claim 83 further comprising the step of providing an instruction signal to remove the substrate from the chamber, end processing, or adjust process conditions, in relation to the evaluation step.

86. A method according to claim 85 comprising providing the instruction signal at the beginning of processing of the substrate.

87. A method according to claim 83 wherein the amplitude change comprises a change in dynamic variance of the amplitude.

88. A substrate processing apparatus comprising:

(a) a chamber capable of processing a substrate;

(b) a radiation source capable of providing radiation that is at least partially reflected from the substrate during processing;

(c) a radiation detector adapted to detect the reflected radiation and generate a signal; and

(d) a computer having a memory capable of operating a computer-readable program embodied on a computer-readable medium, the computer readable program including program code to receive the signal and evaluate an amplitude change of the reflected radiation in relation to a range of amplitude changes for a batch of substrates.

89. An apparatus according to claim 88 wherein the program code evaluates the amplitude change to determine if the amplitude change is within the range.

90. An apparatus according to claim 88 wherein the program code is further adapted to provide an instruction signal to remove the substrate from the chamber, end processing, or adjust process conditions, in response to the evaluation of the amplitude change.

91. A substrate processing apparatus comprising:

a chamber capable of processing a substrate;

a radiation source capable of providing radiation that is at least partially reflected from a substrate in the chamber;

a radiation detector adapted to detect the reflected radiation and generate a signal; and

a controller adapted to receive the signal and evaluate the signal to determine if a thickness of an insulator on the substrate is sufficiently large to reduce electrical breakdown through the insulator.

92. An apparatus according to claim 91 wherein the controller evaluates an amplitude of the reflected radiation.

93. An apparatus according to claim 91 wherein the controller evaluates a change in the amplitude of the reflected radiation relative to a calculated or stored range of amplitude changes for a batch of substrates.

94. An apparatus according to claim 93 wherein the controller evaluates a change in amplitude comprising a dynamic variance of the amplitude.

95. A method of processing a substrate in a process zone, the method comprising the steps of:

(a) placing the substrate in the process zone;

(b) detecting radiation reflected from the substrate before, during, or after processing of the substrate; and

(c) evaluating the reflected radiation to determine if a thickness of an insulator on the substrate is sufficiently large to reduce a possibility of electrical breakdown through the insulator.

96. A method according to claim 95 comprising evaluating an amplitude of the reflected radiation.

97. A method according to claim 96 comprising evaluating a change in the amplitude of the reflected radiation relative to a calculated or stored range of amplitude changes for a batch of substrates.

98. A method according to claim 96 comprising evaluating a change in amplitude comprising a dynamic variance of the amplitude.

99. A substrate processing apparatus comprising:

(a) a chamber capable of processing a substrate;

(b) a radiation source capable of providing radiation that is at least partially reflected from the substrate during processing;

(c) a radiation detector adapted to detect the reflected radiation and generate a signal; and

(d) means for evaluating the signal to determine a thickness of an insulator on the substrate before completion of processing.

100. An apparatus according to claim 99 wherein the means comprises a computer having a memory capable of operating a computer-readable program embodied on a computer-readable medium, the computer readable program including program code to receive the signal and evaluate an amplitude change of the signal.

101. An apparatus according to claim 100 comprising means for evaluating the amplitude change of the signal relative to a calculated or stored range of amplitude changes for a batch of substrates.

102. A substrate processing apparatus comprising:

a chamber capable of processing a substrate;

a radiation source capable of providing radiation that is at least partially reflected from a substrate in the chamber;

a radiation detector adapted to detect the reflected radiation and generate a signal;

a controller adapted to receive the signal and generate a set of data relating to a property of the substrate; and

a factory automation host computer to receive the data.

103. An apparatus according to claim 102 wherein the factory automation host computer comprises a software program for substrate evaluation, process evaluation or process control.

104. An apparatus according to claim 103 wherein the software program evaluates the data to determine statistical process control parameters.

105. An apparatus according to claim 102 wherein the factory automation host computer is adapted to provide an instruction signal to remove the substrate from the chamber, end processing, or adjust process conditions, upon a determination of an unsuitable property of the substrate or an unsuitable process parameter.

106. An apparatus according to claim 105 wherein the factory automation host computer is adapted to provide the instruction signal at the beginning or end of processing of the substrate.